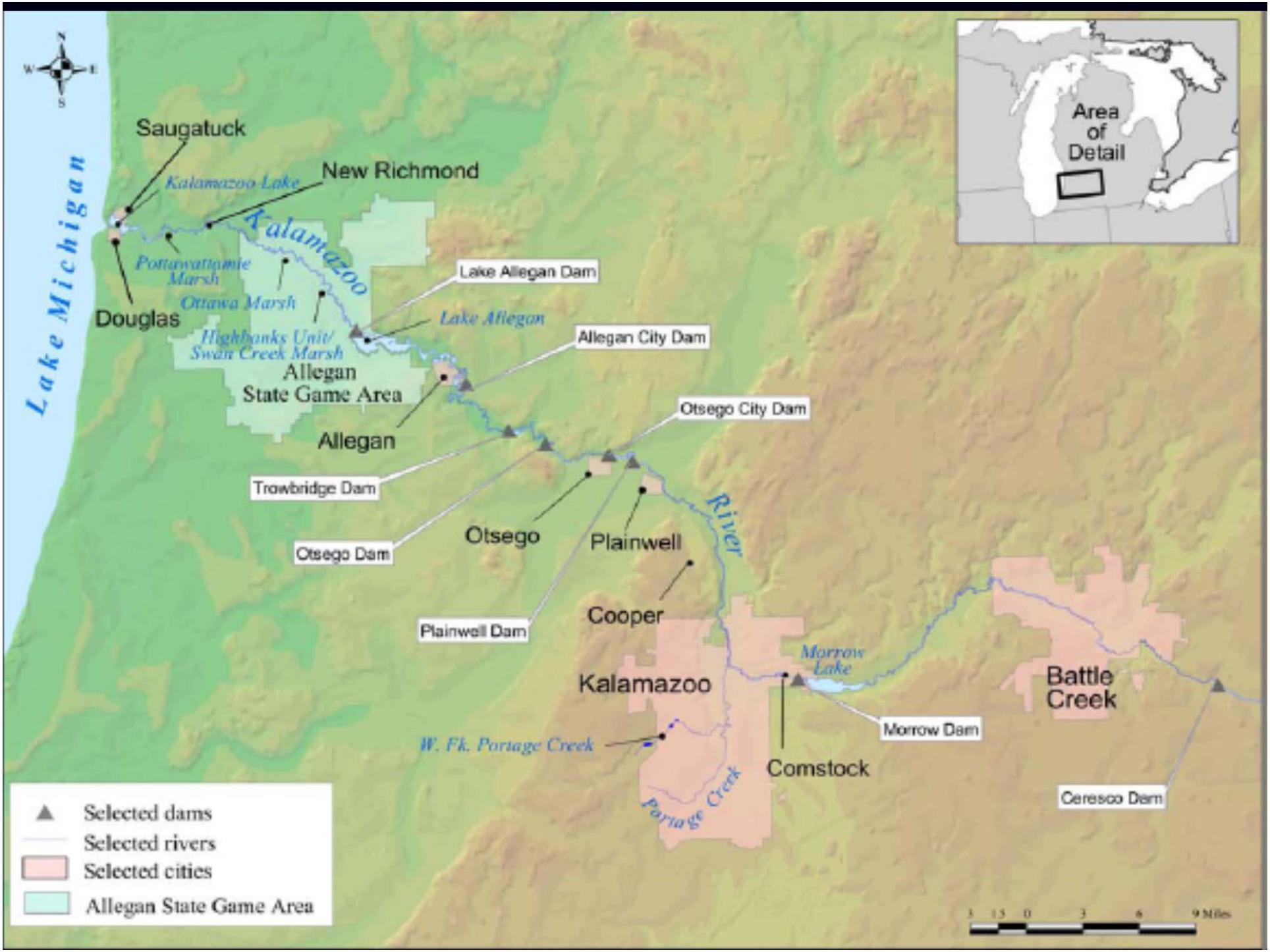
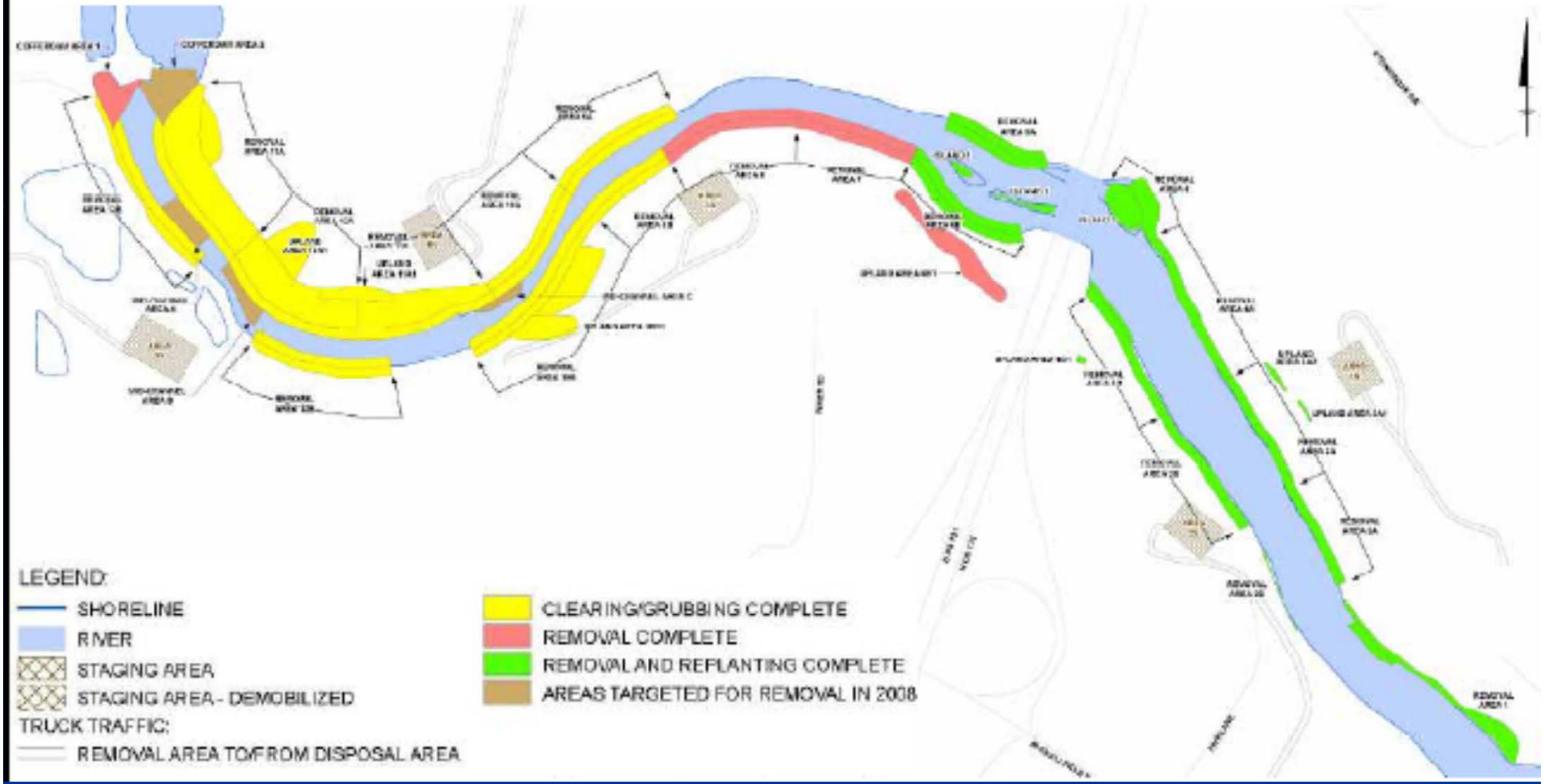
Channel Morphology Assessment for the Plainwell Dam Removal Site

July 3, 2012

Lansing, MI


Lake Michigan
Saugatuck
New Richmond
Kalamazoo Lake
Kalamazoo
River
Pottawattamie Marsh
Ottawa Marsh
Highbanks Unit/ Swan Creek Marsh
Douglas
Lake Allegan Dam
Lake Allegan
Allegan City Dam
Allegan State Game Area
Allegan
Otsego City Dam
Trowbridge Dam
Otsego Dam
Otsego
Plainwell
Plainwell Dam
Cooper
Kalamazoo
Morrow Lake
Morrow Dam
Battle Creek
W. Fk. Portage Creek
Portage Creek
Comstock
Ceresco Dam
Area of Detail
Selected dams
Selected rivers
Selected cities
Allegan State Game Area
9 Miles

Plainwell TCRA – 2007 Overview



Plainwell TCRA, AOC, VIII- Work to be performed
Section 18

Post-Removal Site Control. Upon the third anniversary date of MDNR's receipt of the Notice of Completion of Work pursuant to Paragraph 77, MDNR agrees to perform the post-removal site control activities described in Section 5.6.2 through 5.6.5 of the Work Plan. With regard to the reporting requirements of Section 5.6.5 of the Work Plan, MDNR shall submit the required report annually until such time that U.S. EPA and MDNR agree that the banks addressed in the removal action required by this Settlement Agreement are sufficiently stabilized, and the vegetation sufficiently restored, such that no further annual reporting is necessary. After U.S. EPA and MDNR so agree, MDNR shall submit a report to U.S. EPA only in those years when a significant change has occurred in the condition of the vegetation or banks within the Plainwell Impoundment, and/or when MDNR has taken a significant action to address a change in the condition of the vegetation or banks within the Plainwell Impoundment.

5.6.2 Bank Monitoring

The onsite restoration activities described in Sections 3.7 and 3.8 will be monitored to document progress toward the restoration goals. Monitoring will include visual observations of restored bank stability and in-channel sediment conditions, as well as evaluation of seeded and planted vegetation. Monitoring of restored bank areas for signs of erosion or bank failure will be performed annually for 3 years, but will focus on post 2- year storm events. A 2-year or greater storm would represent a high-stress exposure for restored banks and a relatively high probability for potential bank failure. If areas of significant erosion or bank failure are observed, the need for bank repair maintenance activities will be discussed with EPA.

TCRA Construction Completion Report
1.3 Overview of Response Actions and Summary of Work Performed

2. Cut-back and stabilization of river banks to mitigate exposures to PCB-contaminated banks, control future bank erosion, and achieve a stable channel.

11. Establishment of a stable river channel post-removal and re-vegetation with native plant species.

Goal: Estimate equilibrium channel dimensions at the Plainwell Dam removal site

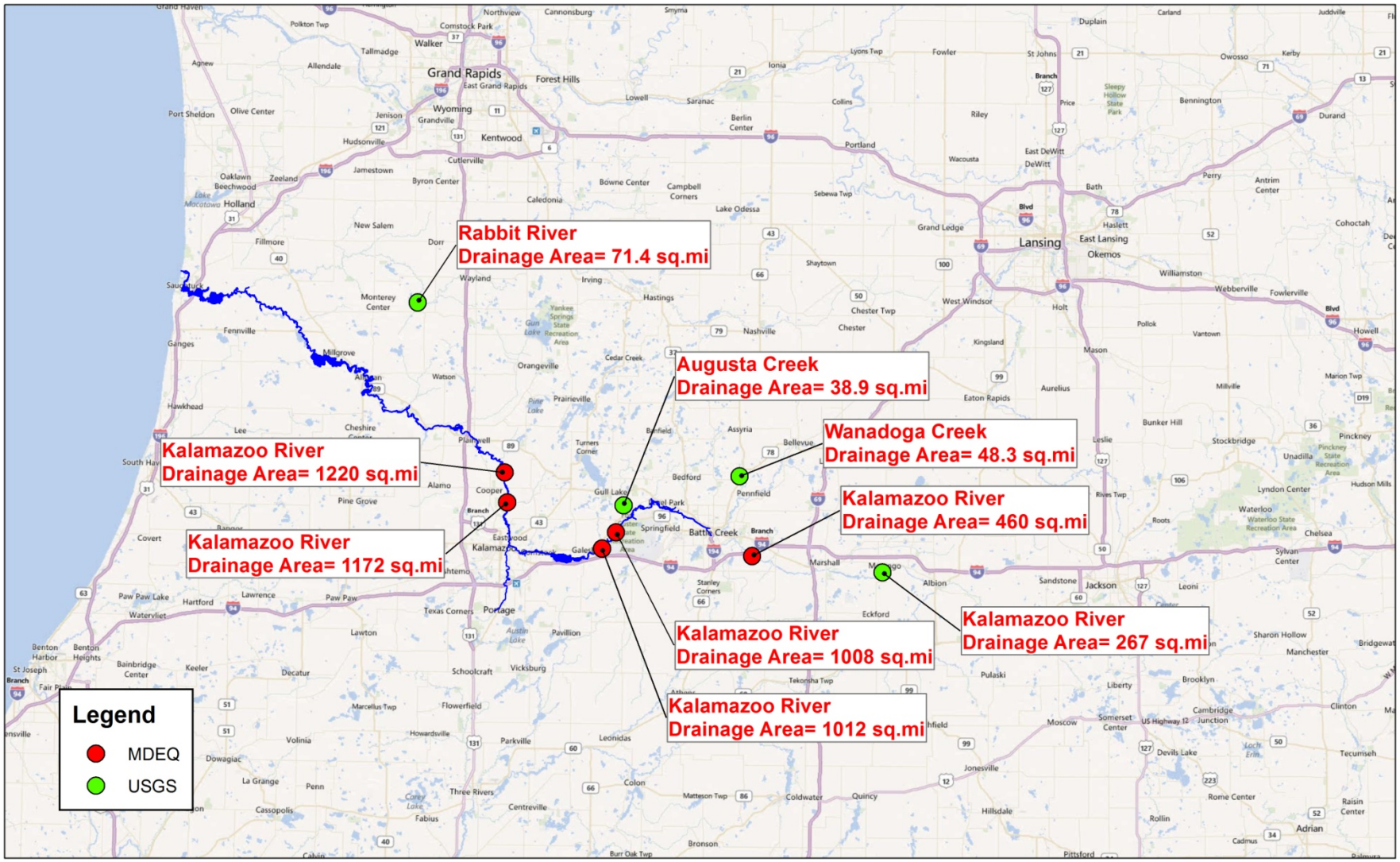
Activities:

- **Identify reference reaches representing stable stream conditions within the Kalamazoo River**
- **Compare reference reaches to existing measurements at the former Plainwell impoundment site**
- **Predict equilibrium channel dimensions at the Plainwell site**

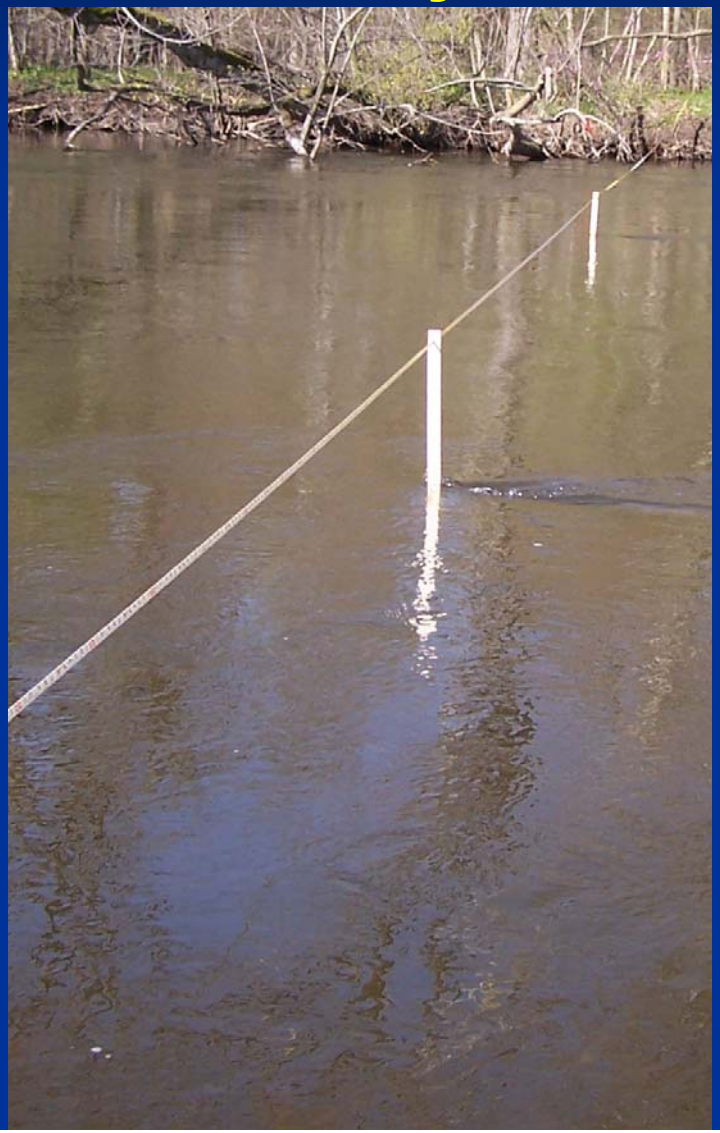
How Reference Reaches Were Selected

- **Physical Indicators**
  - Obvious **riffle** reach
  - Consistent elevation of **depositional flat** at riffle crest (clear bankfull indicator), similar to other nearby reaches
  - Stable **bank vegetation**
  - Not affected by **dams**

Also used data from USGS


Rabbit River
Drainage Area= 71.4 sq.mi
Augusta Creek
Drainage Area= 38.9 sq.mi
Wanadoga Creek
Drainage Area= 48.3 sq.mi
Kalamazoo River
Drainage Area= 1220 sq.mi
Kalamazoo River
Drainage Area= 460 sq.mi
Kalamazoo River
Drainage Area= 1172 sq.mi
Kalamazoo River
Drainage Area= 267 sq.mi
Kalamazoo River
Drainage Area= 1008 sq.mi
Kalamazoo River
Drainage Area= 1012 sq.mi
Legend
MDEQ
USGS

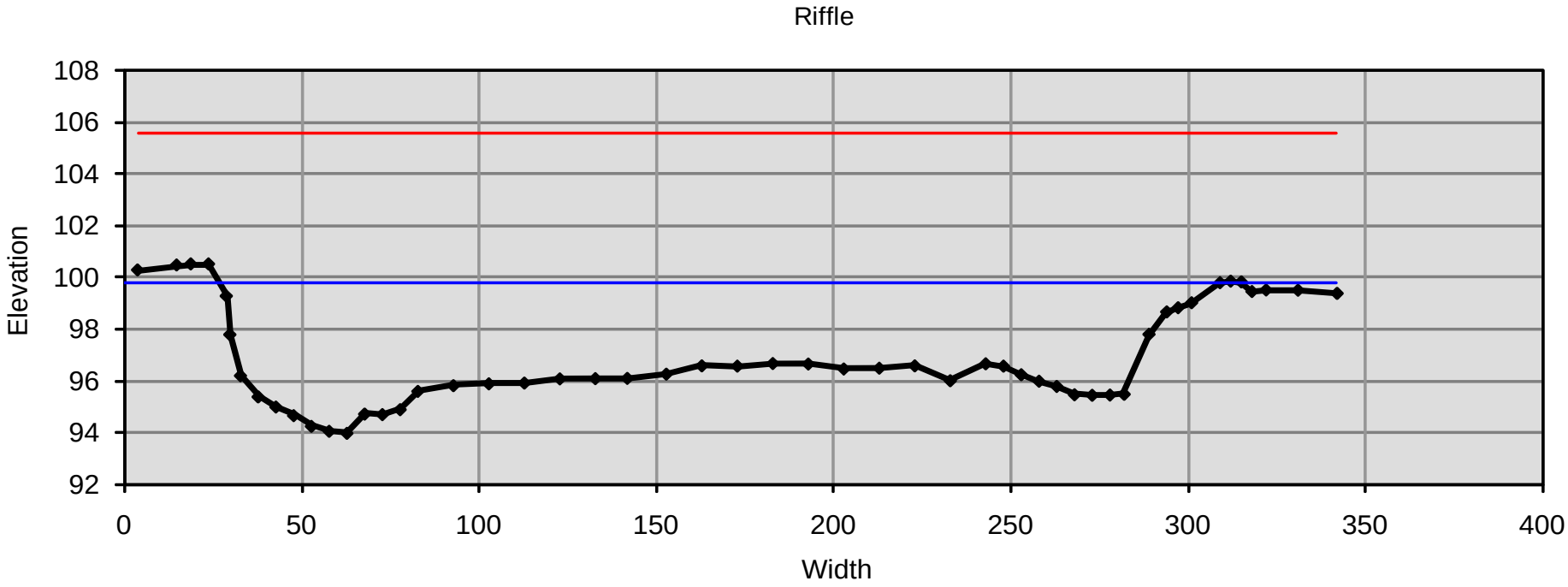
Channel dimension surveys



RR1

Cross Section

Reference Reach RR1



Bankfull Dimensions	
1019.4	x-section area (ft.sq.)
308.8	width (ft)
3.3	mean depth (ft)
5.8	max depth (ft)
310.9	wetted parimeter (ft)
3.3	hyd radi (ft)
93.6	width-depth ratio

Flood Dimensions	
---	W flood prone area (ft)
---	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
7	threshold grain size (mm):

Bankfull Flow	
3.2	velocity (ft/s)
3282.5	discharge rate (cfs)
0.31	Froude number

Flow Resistance	
0.027	Manning's roughness
0.06	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
0.07	channel slope (%)
0.14	shear stress (lb/sq.ft.)
0.27	shear velocity (ft/s)
0.46	unit strm power (lb/ft/s)

Created **"local reference curves"** using our field surveys plus a subset of the southern Lower Peninsula regional curve data (USGS, 2009)

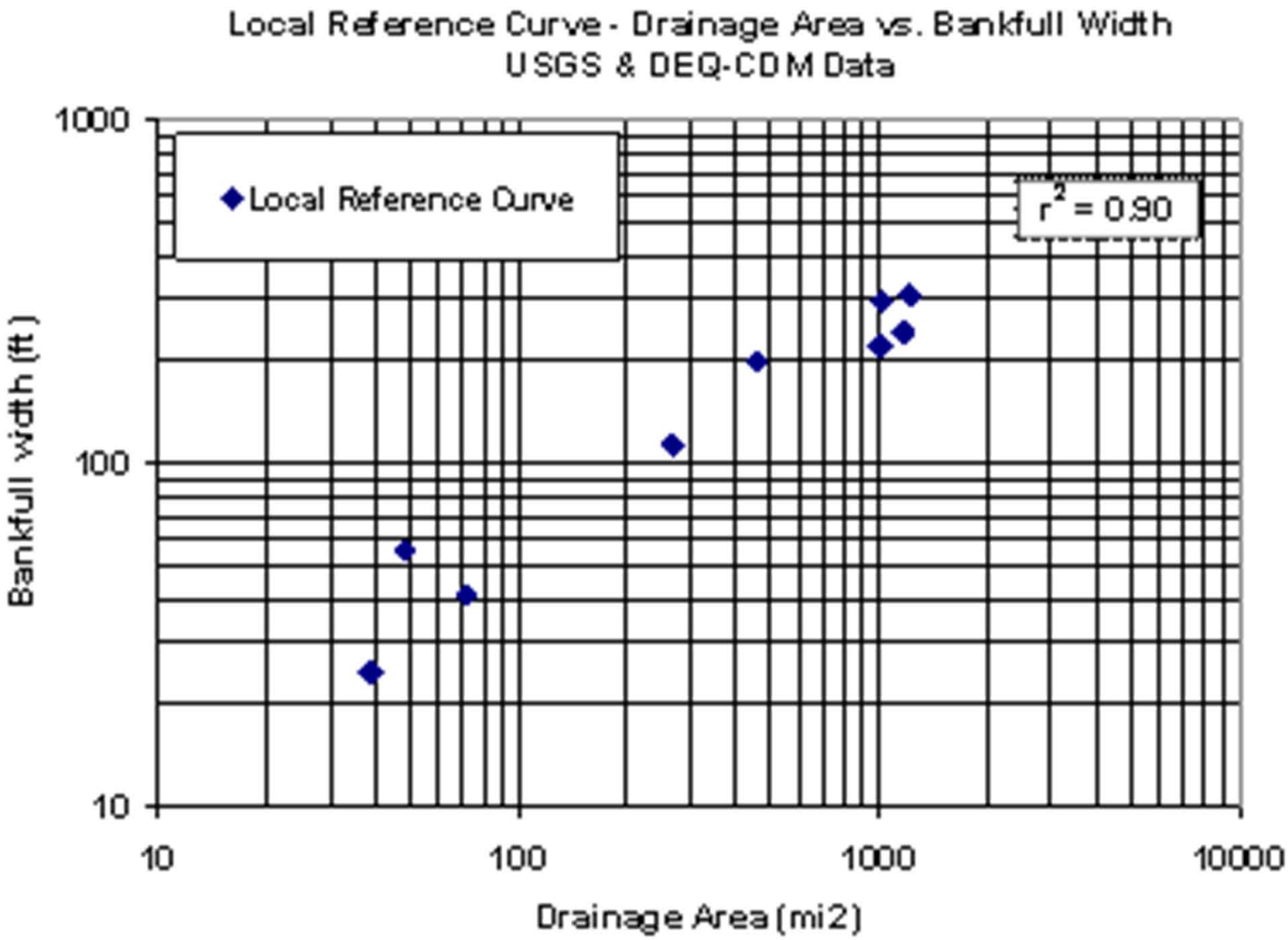
USGS
science for a changing world

Prepared in cooperation with the Michigan Department of Environmental Quality, Michigan Department of Transportation, U.S. Army Corps of Engineers, and U.S. Fish and Wildlife Service

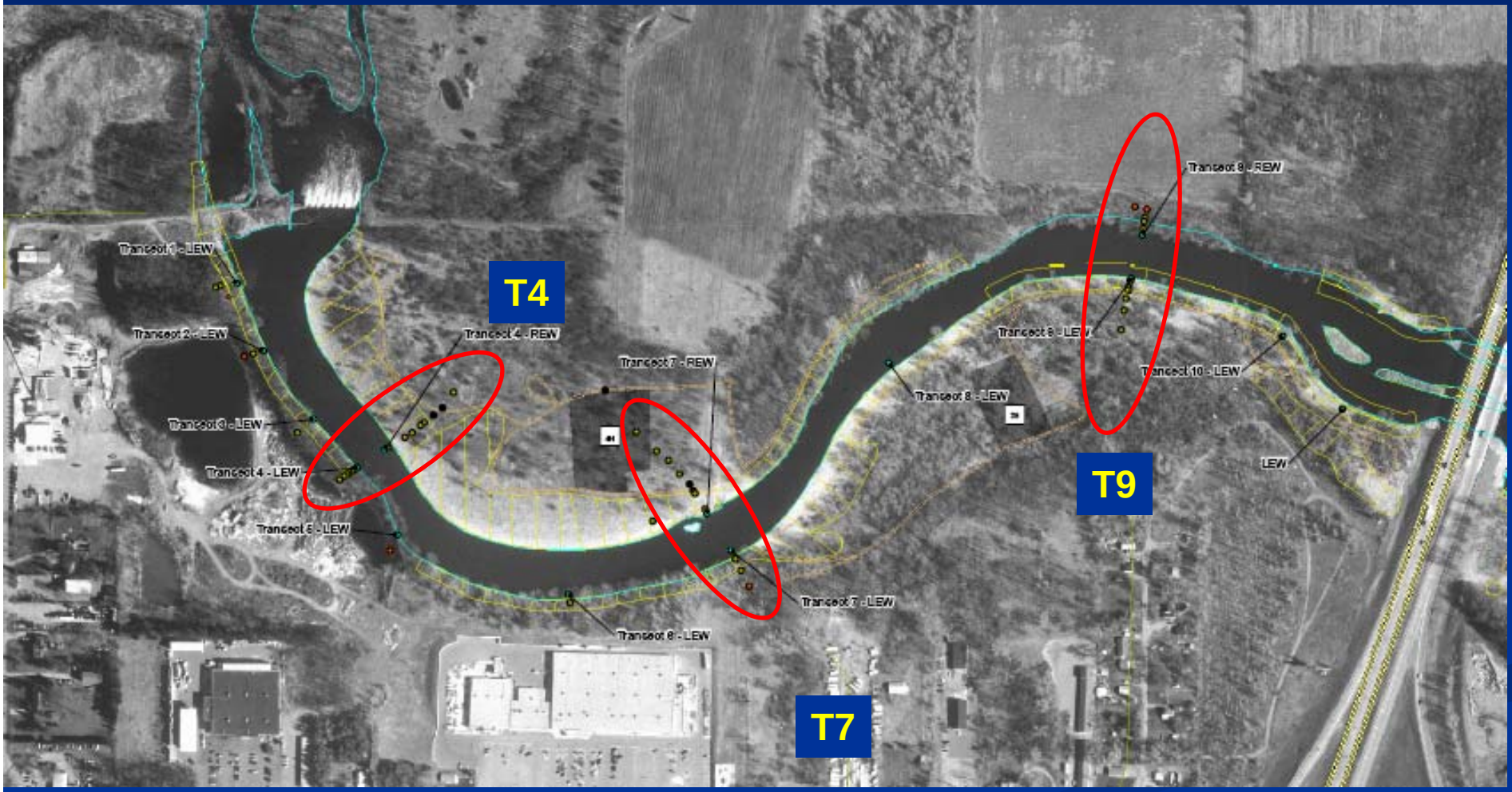
Estimated Bankfull Discharge for Selected Michigan Rivers and Regional Hydraulic Geometry Curves for Estimating Bankfull Characteristics in Southern Michigan Rivers

Scientific Investigations Report 2009–5133

U.S. Department of the Interior
U.S. Geological Survey


Local Reference Curve - Drainage Area vs. Bankfull Width
USGS & DEQ-CDM Data
Local Reference Curve
r2 = 0.90
Bankfull width (ft)
1000
100
10
10
100
1000
10000
Drainage Area (mi2)

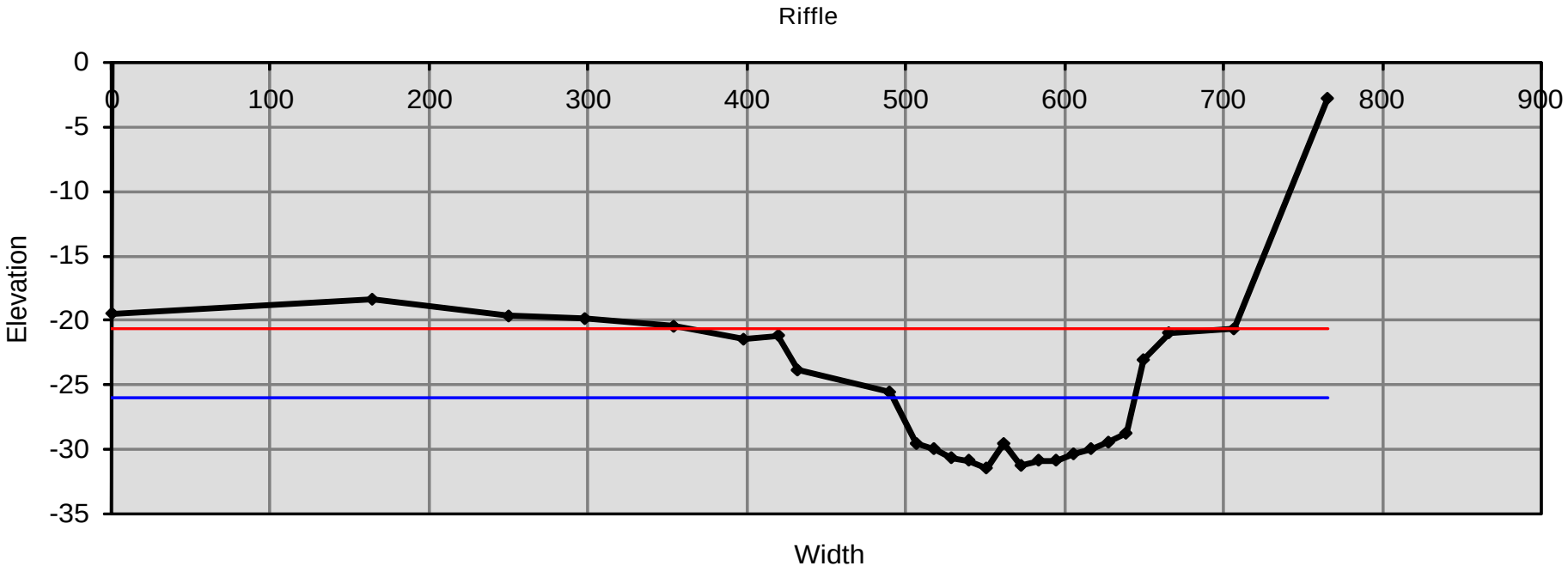
Plainwell Transects



T7

Cross Section 4

Plainwell Transect 7



Bankfull Dimensions	
601.8	x-section area (ft.sq.)
152.1	width (ft)
4.0	mean depth (ft)
5.4	max depth (ft)
153.6	wetted parimeter (ft)
3.9	hyd radi (ft)
38.4	width-depth ratio

Flood Dimensions	
344.2	W flood prone area (ft)
2.3	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

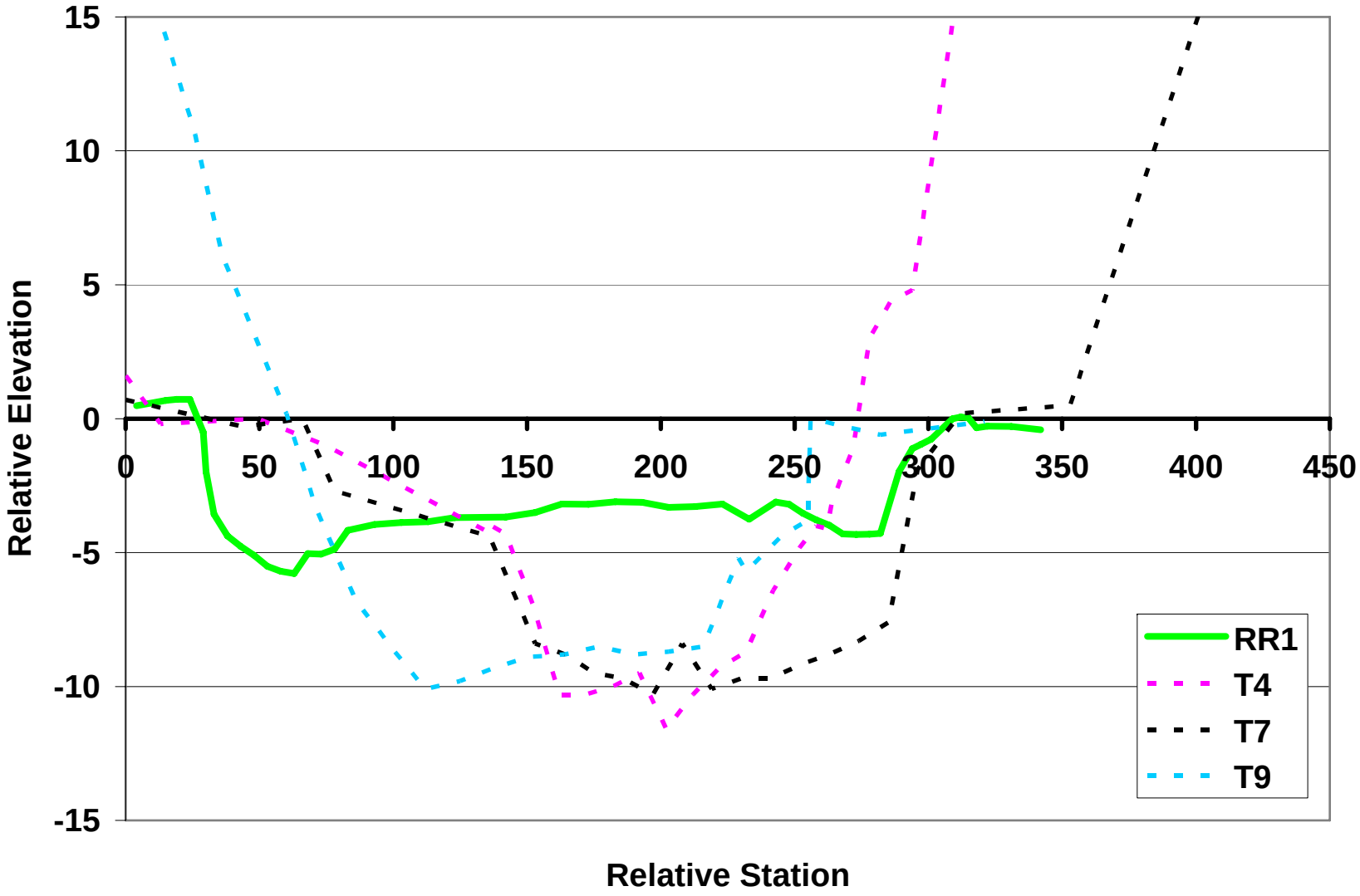
Materials	
---	D50 (mm)
---	D84 (mm)
17	threshold grain size (mm):

Bankfull Flow	
5.1	velocity (ft/s)
3085.8	discharge rate (cfs)
0.46	Froude number

Flow Resistance	
0.027	Manning's roughness
0.05	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

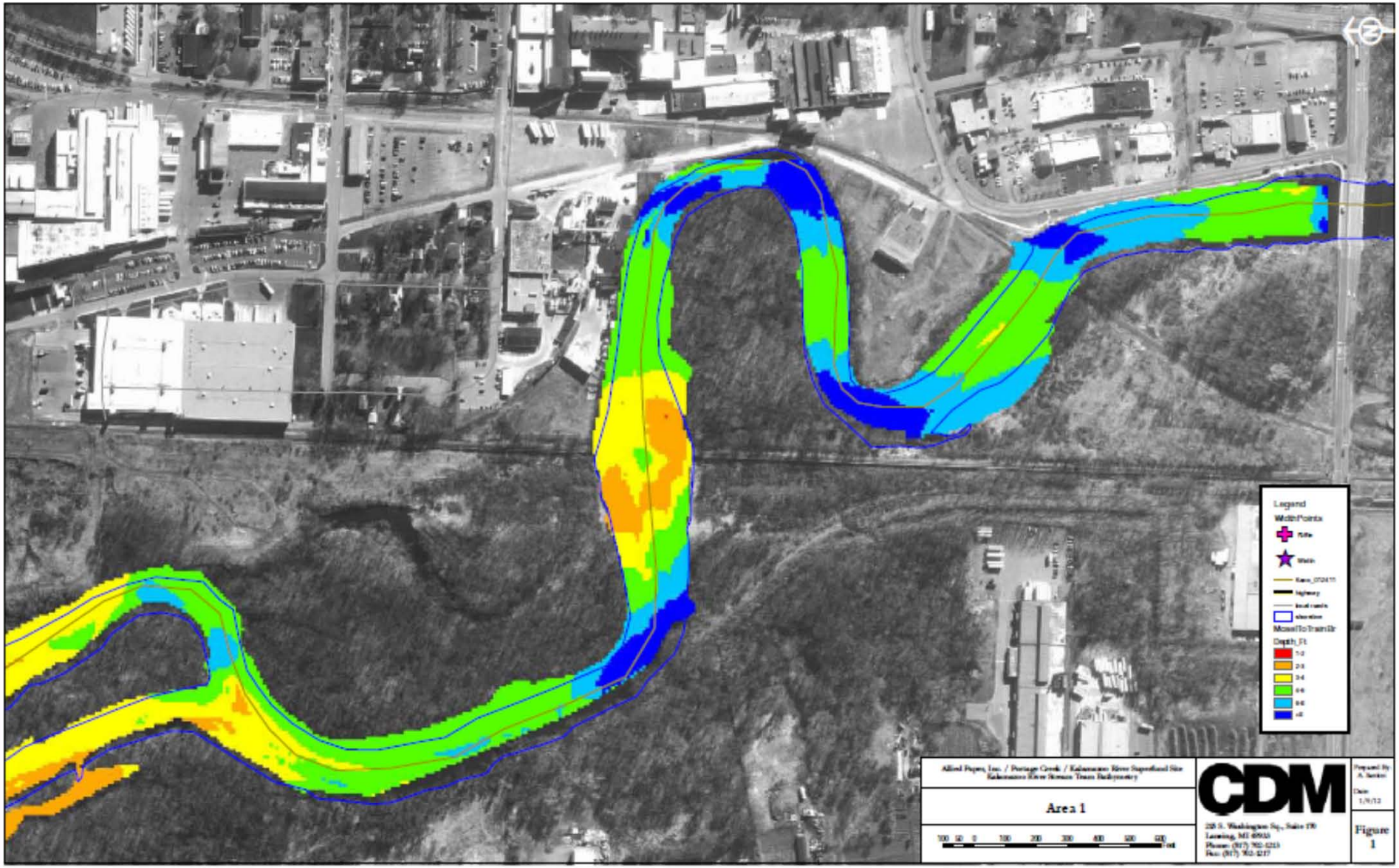
Forces & Power	
0.14	channel slope (%)
0.34	shear stress (lb/sq.ft.)
0.42	shear velocity (ft/s)
1.77	unit strm power (lb/ft/s)

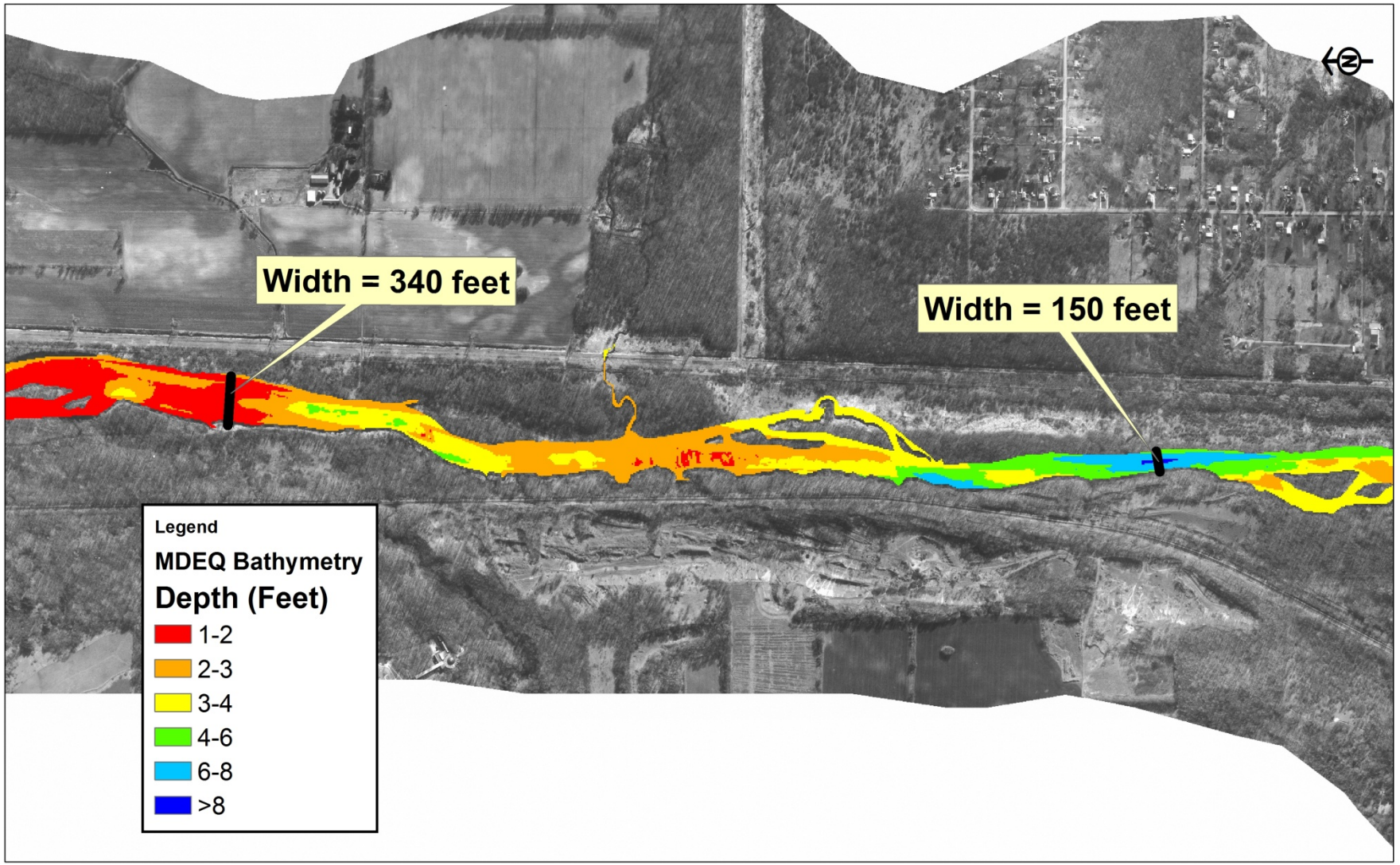
Reference Reach RR1 vs. Plainwell Transects 4, 7, and 9



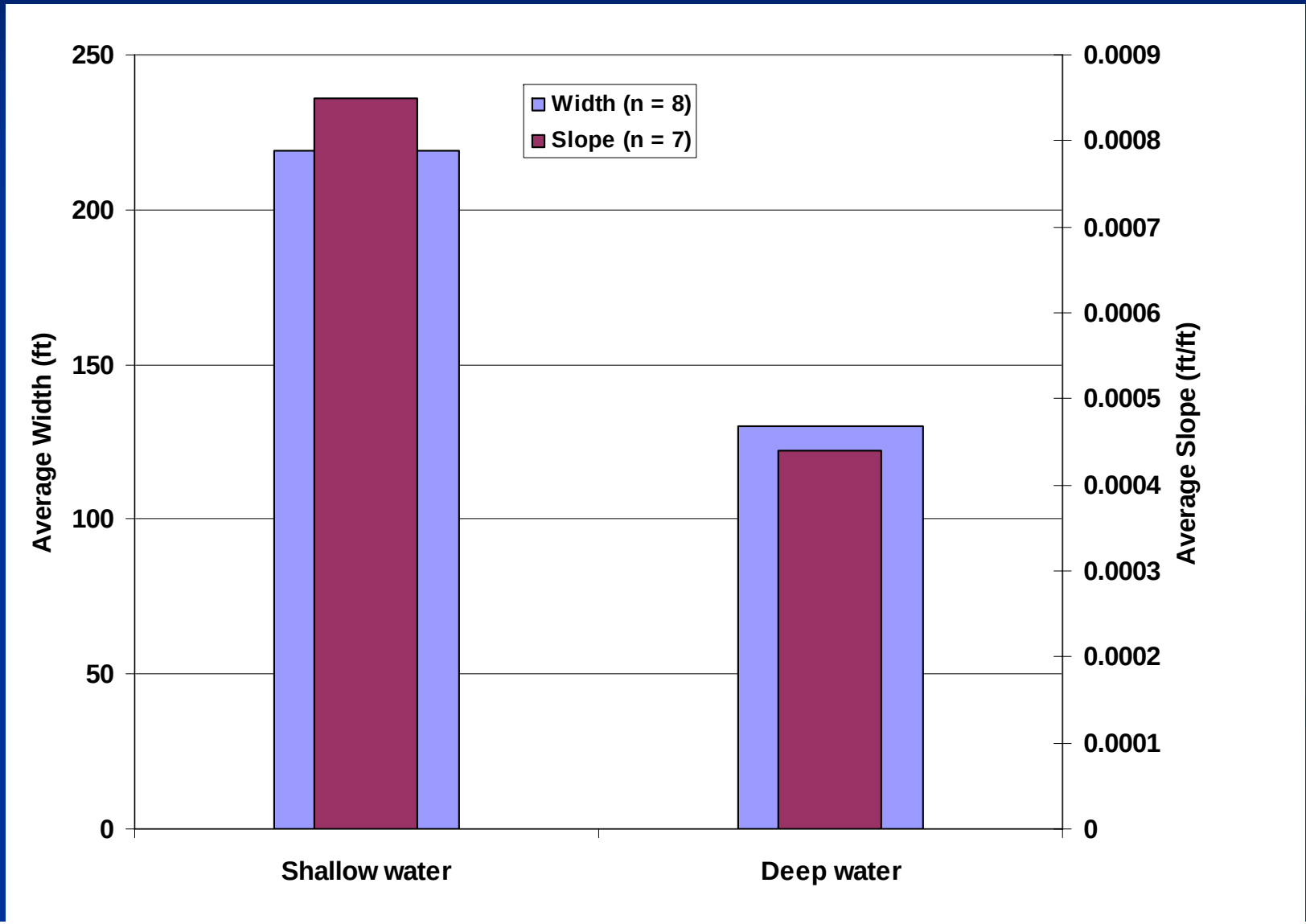
Bathymetric surveys

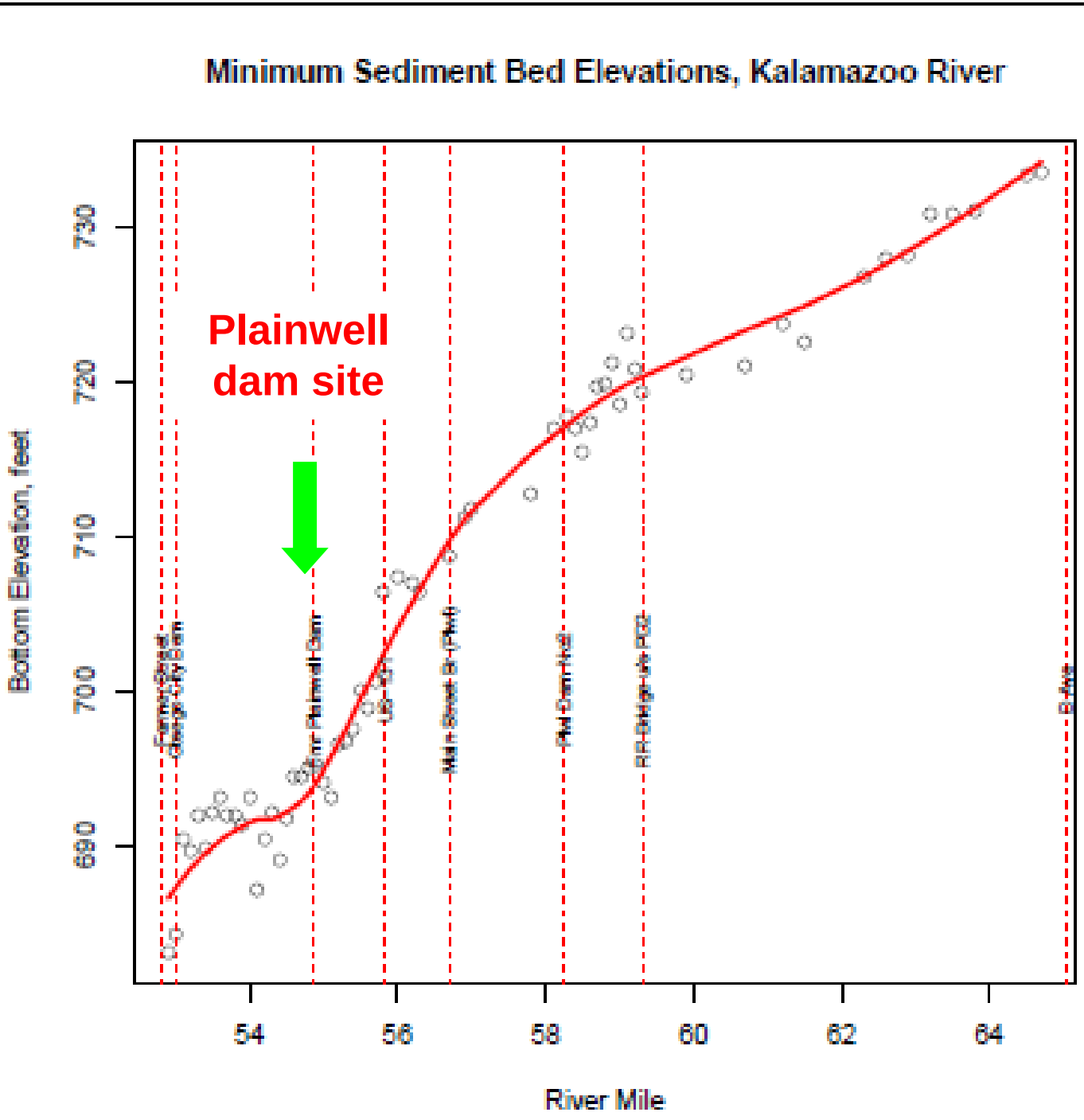
Yellow = shallow, blue = deep



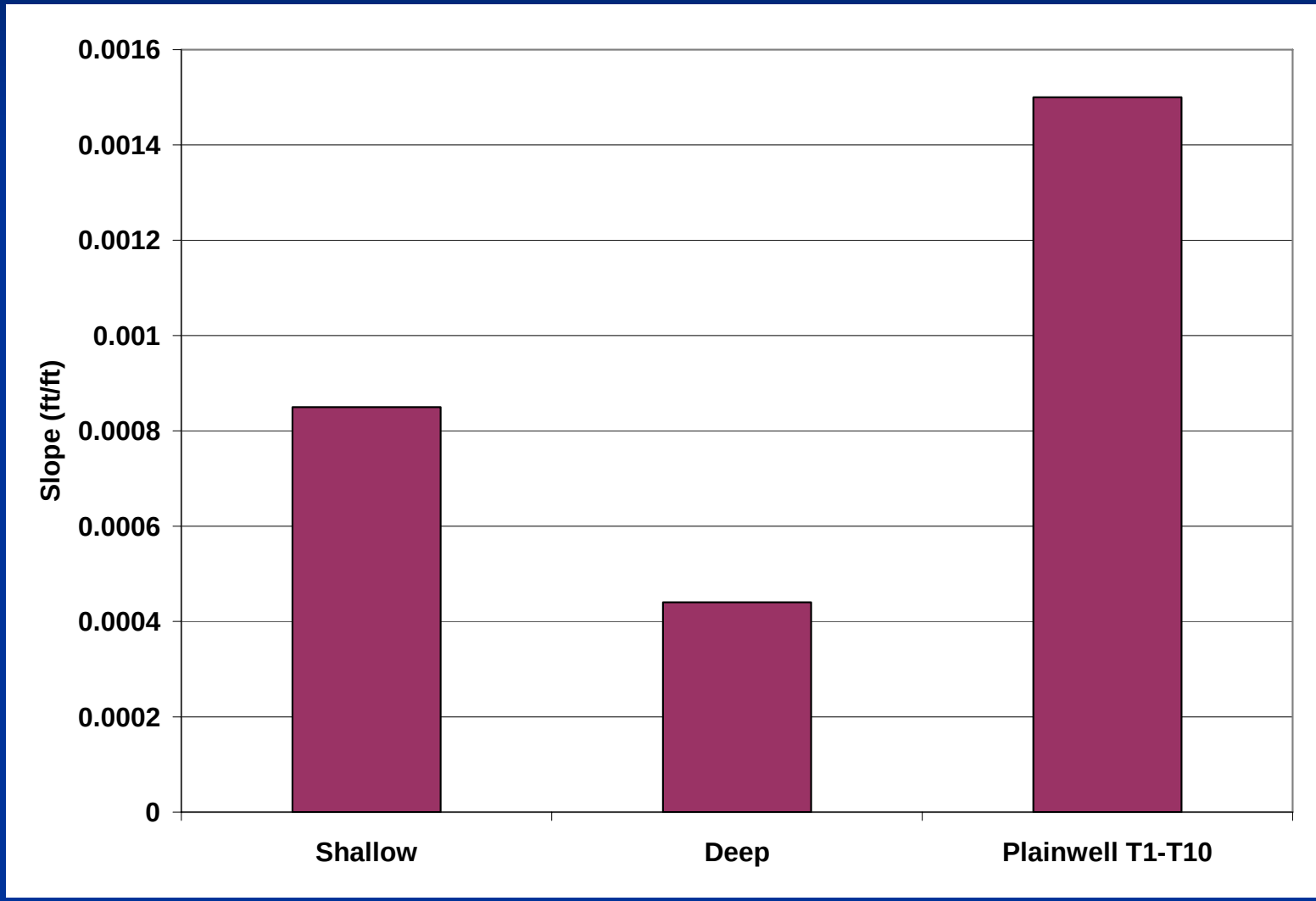

Width = 340 feet
Width = 150 feet
Legend
MDEQ Bathymetry
Depth (Feet)
1-2
2-3
3-4
4-6
6-8
>8

Result 1: Steep reaches are shallow and shallow reaches are wide

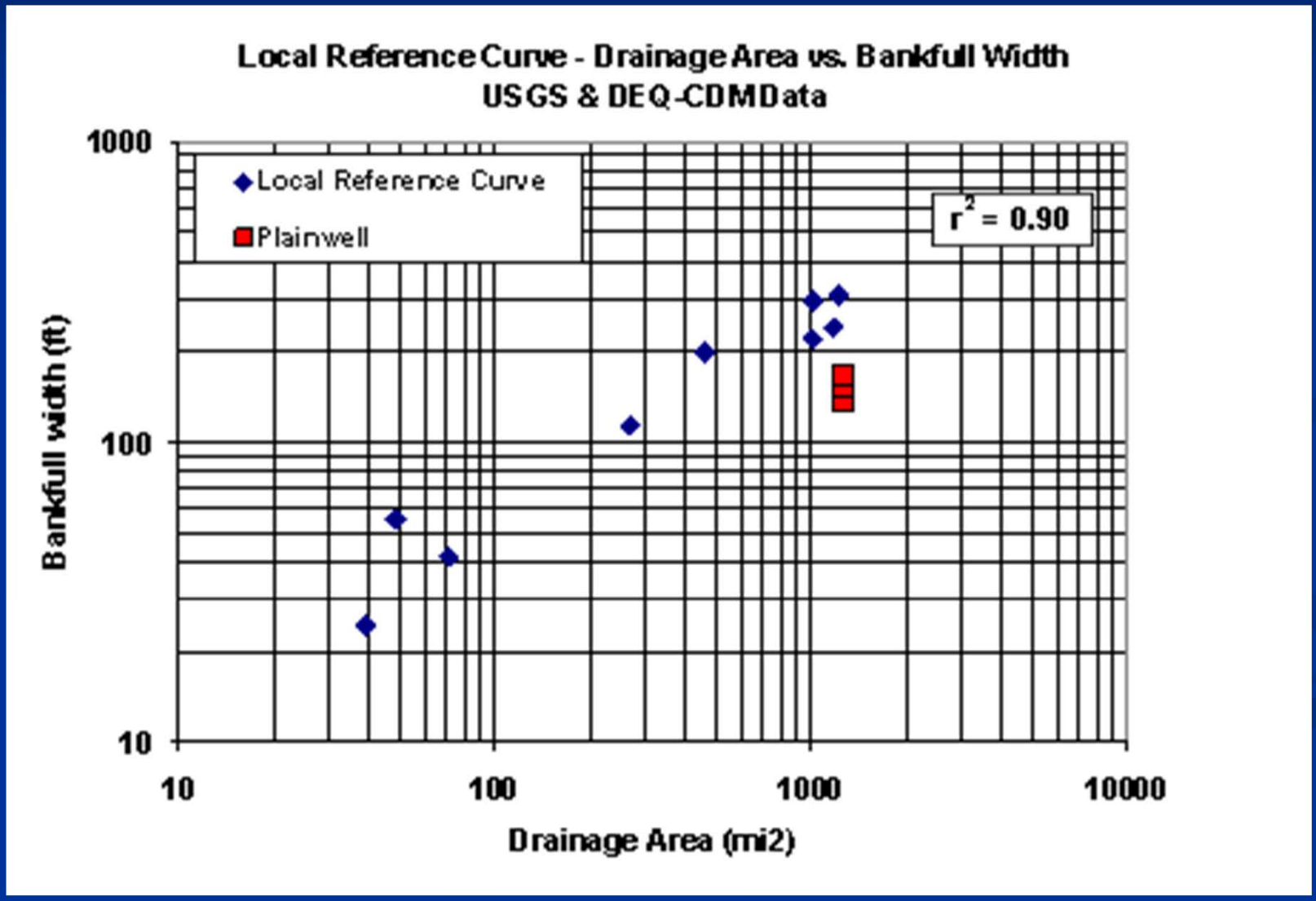



Minimum Sediment Bed Elevations, Kalamazoo River
Plainwell dam site
Bottom Elevation, feet
690
700
710
720
730
54
56
58
60
62
64
River Mile

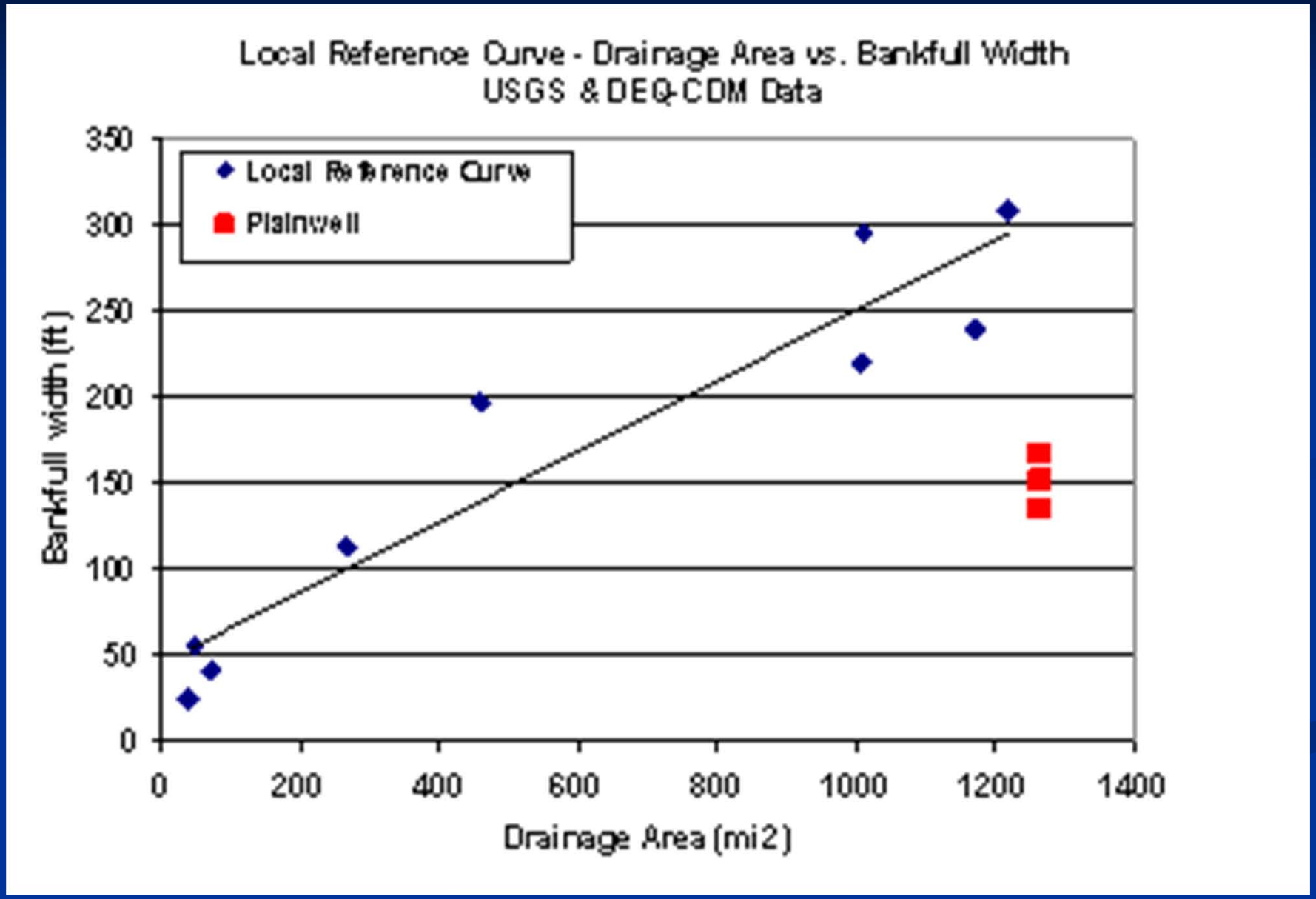
Result 2: the Plainwell dam site is steep – even steeper than shallow riffles elsewhere



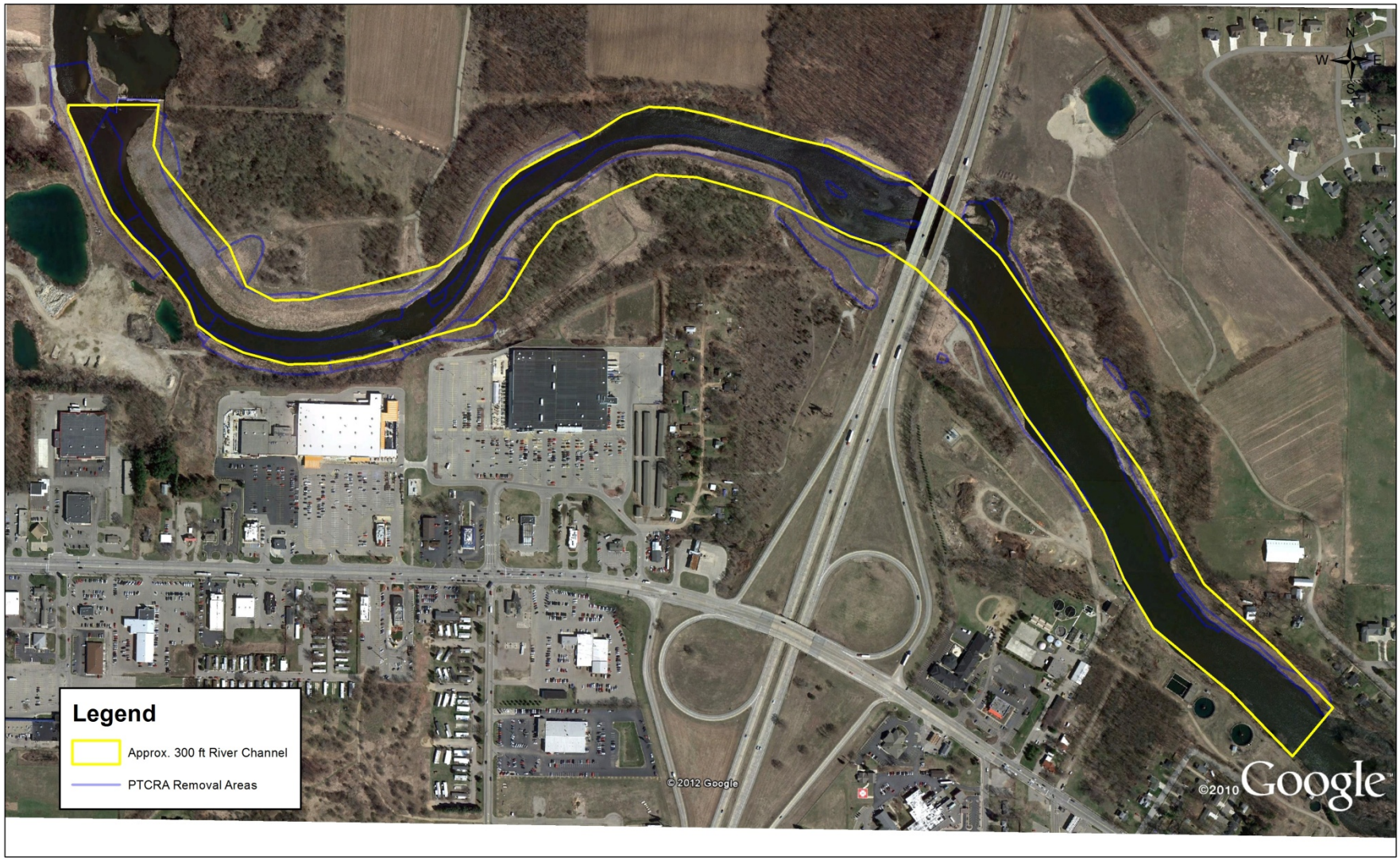
Result 3: Local reference curves allow estimation of how wide the steep Plainwell reaches will become



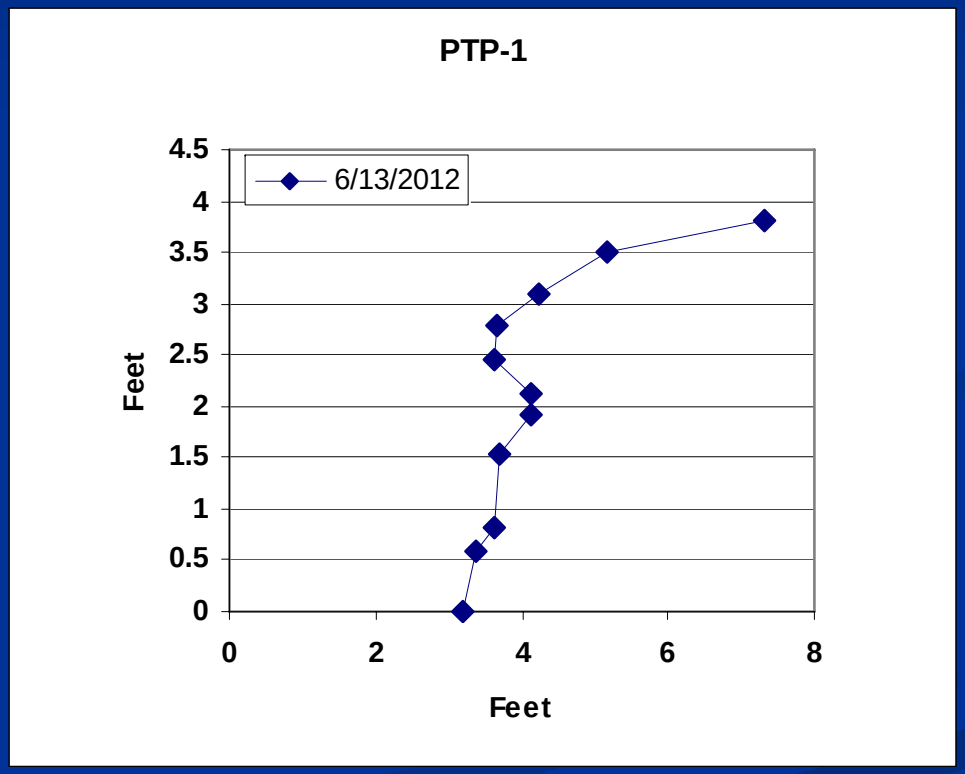
Result 3: same graph, in “normal space”



One possible future configuration…



Toe pins for bank erosion rates



Conclusions & Recommendations

- **Channel width** at Plainwell is currently **~ 55 %** of similarly steep reaches in this part of the watershed.
- ***Therefore the Plainwell Channel may eventually be 150' wider than current conditions***
- **Future dam removals** should use the Kalamazoo River **local reference curves** to design channel

State Implications

1. No action
2. Preemptively excavate floodplain
3. Armor entire channel
4. Combination of the above

State Implications

1. No action

- Pros
  - Cheap
  - Implementable
- Cons
  - Excessive sediment load
  - Remobilization of contaminants into the aquatic system
  - Liability arguments

State Implications

2. Preemptively excavate floodplain

- Pros
  - Removes contaminant threat
  - Achieves Stable Channel Objective
  - Removes excessive sedimentation risk
- Cons
  - Cost
  - Institutional support

State Implications

3. Armor entire channel

- Pros
  - Removes contaminant threat
  - Achieves Stable Bank Objective
- Cons
  - Cost
  - Channel remains in an unstable configuration (down cutting/perpetual bank maintenance)
  - Propagation of energy downstream (increasing risk of downstream erosion)
  - Loss of NRD Benefits

Questions?